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DEPARTMENT OF THE ARMY 02221.TD  
CORPS OF ENGINEERS, TULSA DISTRICT JAN 97  
TULSA DISTRICT GUIDE SPECIFICATION  
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SECTION 02221

EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS

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NOTE: This guide specification covers the requirements for excavation, filling and backfilling, dewatering, shoring, and grading for building construction. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.  
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1 GENERAL

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NOTE: See Additional Notes A and B.  
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1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.  
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The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 422	(1963; R 1990) Particle Size Analysis of Soils
ASTM D 1556	(1990) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))
ASTM D 2167	(1994) Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D 2216	(1992) Laboratory Determination of Water (Moisture) Content of Soil, and Rock&
ASTM D 2487	(1993) Classification of Soils for Engineering Purposes
ASTM D 2922	(1991) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 2937	(1994) Density of Soil in Place by the Drive-Cylinder Method
ASTM D 4253	(1993) Maximum Index Density of Soils Using a Vibratory Table
ASTM D 4318	(1993) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

## 1.2 DEFINITIONS

### 1.2.1 Degree of Compaction

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**NOTE: ASTM D 1557 may not be applicable for certain free-draining types of soils, in which case the applicable requirements will be substituted. See ASTM D 1557 for details.**  
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Degree of compaction is a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D 1557 or ASTM D 4253. ASTM D 1557 shall be used for soils containing 15 percent or more passing the No. 200 sieve (fines). ASTM D 4253 shall be used for soils containing 5 percent or less fines. The maximum laboratory dry density for soils containing between 5 and 15 percent fines shall be determined by the above procedure yielding the highest laboratory dry density. The percentage of material passing the no. 200 sieve shall be determined in accordance with ASTM D 4253. Degree of compaction shall be expressed as a percentage of the maximum laboratory dry density obtained by the appropriate procedure as defined above. Percentage of maximum laboratory dry density has been abbreviated hereinafter as percent laboratory maximum density or percent maximum density.

## 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Satisfactory Materials

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**NOTE: See Additional Note C.**  
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Satisfactory materials include materials classified in ASTM D 2487 as GW, GP, SW, GC, GM, SP, SM, SC, AND CL and shall be free of trash, debris, roots or other organic matter, or stones larger than 3 inches in any dimension.

#### 2.1.2 Unsatisfactory Materials

Unsatisfactory materials include materials classified in ASTM D 2487 as Pt, OH, OL, ML, MH, AND CH and any other materials not defined as satisfactory.

#### 2.1.3 Cohesionless and Cohesive Materials

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**NOTE: See Additional Note D.**

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Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic.

#### 2.1.4 Nonexpansive Fill

Nonexpansive fill is a satisfactory material having a plasticity index equal to or less than 12 when tested in accordance with ASTM D 4318.

### 2.2 CAPILLARY WATER BARRIER

Capillary Water Barrier shall consist of clean, crushed, nonporous rock, crushed gravel, or uncrushed gravel. The maximum particle size shall be 37.5 mm 1-1/2 inches and no more than 2 percent by weight shall pass the 4.75 mm No. 4 sieve.

## 3 EXECUTION

### 3.1 CLEARING AND GRUBBING

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**NOTE: When clearing and grubbing are specified in another section, use the sentence in the first set of brackets. Otherwise use the remainder of the paragraph.**

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[Clearing and grubbing is specified in Section 02110 CLEARING AND GRUBBING.]  
[The areas within lines 1.500 m 5 feet outside of each building and structure line shall be cleared and grubbed of trees, stumps, roots, brush and other vegetation, debris, existing foundations, pavements, utility lines, structures, fences, and other items that would interfere with construction operations. Stumps, logs, roots, and other organic matter shall be completely removed and the resulting depressions shall be filled with satisfactory material, placed and compacted in accordance with paragraph FILLING AND BACKFILLING. Materials removed shall be disposed of [in the designated waste disposal areas] [outside the limits of Government-controlled property at the Contractor's responsibility].]

### 3.2 TOPSOIL

Topsoil shall be stripped to a depth of [\_\_\_\_\_] inches below existing grade within the designated excavations and grading lines and deposited in storage piles for later use. Excess topsoil shall be disposed as specified for excess excavated material.

### 3.3 EXCAVATION

Excavation shall conform to the dimensions and elevations indicated for each building, structure, and footing except as specified hereinafter, and shall include trenching for utility and foundation drainage systems to a point 1.5 m 5 feet beyond the building line of each building and structure, excavation for outside grease interceptors, underground fuel tanks, and all work incidental thereto. Excavation shall extend a sufficient distance from walls and footings to allow for placing and removal of forms. Where nonexpansive fill is indicated below slabs the excavation shall be performed to the depth required to place the required thickness of nonexpansive fill. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed and replaced with nonexpansive material. [Payment therefor will be made in conformance with the CHANGES clause of the CONTRACT CLAUSES.] Satisfactory material removed below the depths indicated without specific direction of the Contracting Officer shall be replaced at no additional cost to the Government to the indicated excavation grade with nonexpansive fill, except that concrete footings shall be increased in thickness to the bottom of the overdepth excavations and over-break in rock excavation. Nonexpansive fill material shall be placed and compacted as specified in paragraph FILLING AND BACKFILLING. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

### 3.4 DRAINAGE AND DEWATERING

#### 3.4.1 Drainage

Surface water shall be directed away from excavation and construction sites so as to prevent erosion and undermining of foundations. The foundation of any shall be protected as required to prevent surface water and rainfall from ponding or being collected within the perimeter of any structure. Diversion ditches, dikes and grading shall be provided and maintained as necessary during construction. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site and the area immediately surrounding the site and affecting operations at the site shall be continually and effectively drained.

#### 3.4.2 Dewatering

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**NOTE: The paragraph will be revised as needed when  
specific methods of dewatering are required.**

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Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 1 meter 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 900 mm 3 feet below the working level.

### 3.5 SHORING

Shoring, including sheet piling, shall be furnished and installed as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Shoring, bracing, and sheeting shall be removed as excavations are backfilled, in a manner to prevent caving.

### 3.6 CLASSIFICATION OF EXCAVATION

Excavation will be unclassified regardless of the nature of material encountered.

### 3.7 BLASTING

Blasting will not be permitted.

### 3.8 UTILITY AND DRAIN TRENCHES

Trenches for underground utilities systems and drain lines shall be excavated to the required alignments and depths. The bottoms of trenches shall be graded to secure the required slope and shall be tamped if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 150 mm 6 inches below the bottom of the pipe, and the overdepth shall be backfilled with nonexpansive fill placed and compacted in conformance with paragraph FILLING AND BACKFILLING.

### 3.9 BORROW

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**NOTE: See Additional Note F.**

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Where satisfactory materials are not available in sufficient quantity from required excavations, approved materials shall be obtained [as specified in [Section 02225 EARTHWORK FOR ROADWAYS, RAILROADS AND AIRFIELDS] [Section 02210 GRADING]].

### 3.10 EXCAVATED MATERIALS

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**NOTE: See Additional Note F.**

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Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required under this section or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of [as specified in Section [02225 EARTHWORK FOR ROADWAYS, RAILROADS AND AIRFIELDS] [02210 GRADING]].

### 3.11 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Excavation to final grade shall not be made until just before concrete is to be placed. Only excavation methods that will leave the foundation rock in a solid and unshattered condition shall be used. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond. Shales shall be protected from slaking or other erosion resulting from ponding or flow of water.

### 3.12 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials. The surface shall be scarified to a depth of 150 mm 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 150 mm 6 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 300 mm 12 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary [to plus or minus [\_\_\_\_\_] percent of optimum moisture] [to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used]. Minimum subgrade density shall be as specified in paragraph FILLING AND BACKFILLING.

### 3.13 FILLING AND BACKFILLING

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**NOTE: See Additional Note G.**

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Satisfactory materials shall be used in bringing fills and backfills to the lines and grades indicated and for replacing unsatisfactory materials. All satisfactory materials placed under buildings, structures, and footings shall be nonexpansive fill. Satisfactory materials shall be placed in horizontal layers not exceeding 200 mm 8 inches in loose thickness, or 150 mm 6 inches when hand-operated compactors are used. After placing, each layer shall be plowed, disked, or otherwise broken up, moistened or aerated as necessary, thoroughly mixed and compacted as specified. Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved,

forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade and shall include backfill for outside grease interceptors and underground fuel tanks. Backfill shall not be placed in wet or frozen areas. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 600 mm 2 feet above sewer lines and 300 mm 1 foot above other utility lines shall be free from stones larger than 25.4 mm 1 inch in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 100 mm 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall. Using the appropriate laboratory maximum dry density test procedure as defined in Part 1 above, each layer of fill and backfill shall be compacted to not less than the percentage of maximum density specified below:

	Percent Laboratory maximum density	
	ASTM D 1557	ASTM D 4253
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Fill, embankment, and backfill		
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Under structures, building slabs, steps, paved areas, around footings, and in trenches	90	95
Under sidewalks and grassed areas	85	90
Nonexpansive fill Subgrade	92	92
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Under building slabs, steps, and paved areas, top 300 mm 12 inches	90	95
Under sidewalks, top 150 mm 6 inches	85	90

Approved compacted subgrades that are disturbed by the Contractor's operations or adverse weather shall be scarified and compacted as specified herein before to the required density prior to further construction thereon. Recomposition over underground utilities and heating lines shall be by hand tamping.

### 3.14 TESTING

Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or may be performed by the Contractor subject to approval. If the Contractor elects to establish testing

facilities, no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved by the Contracting Officer. Field in-place density shall be determined in accordance with ASTM D 1556 or ASTM D 2922. If ASTM D 2922 is used, in-place densities shall be checked by the ASTM D 1556 procedure at a frequency of one sand cone test for each 8 nuclear density tests and not less than one sand cone density test per lift. The sand cone test shall be performed adjacent to the location where a nuclear density test was performed to insure a proper correlation is established between the two density test procedures. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, the material shall be removed, replaced and recompacted to meet specification requirements, at no additional expense to the Government. Tests on recompacted areas shall be performed to determine conformance with specification requirements. Moisture contents shall be determined in accordance with ASTM D 4643 and/or ASTM D 2216. If the ASTM D 4643 procedure is used, moisture contents shall be checked by the ASTM D 2216 procedure once per each 10 ASTM D 4643 tests. The following number of tests, if performed at the appropriate time, shall be the minimum acceptable for each type operation.

### 3.14.1 In-Place Densities

#### 3.14.1.1 In-Place Density of Subgrades

One test per [185] [ ] square meters [\_\_\_\_][2000] square feet or fraction thereof.

#### 3.14.1.2 In-Place Density of Fills and Backfills

One test per [2000][ ] square feet or fraction thereof of each lift for fill or backfill areas compacted by other than hand or hand-operated machines. The density for each lift of fill or backfill materials for trenches, pits, building perimeters or other structures or areas less than 1800 mm 6 feet in width, which are compacted with hand or hand-operated machines shall be tested as follows: One test per each area less than 10 square meters 100 square feet, or one test for each 15 m 50 linear foot of long narrow fills 30 m 100 feet or more in length.

#### 3.14.2 Moisture Content

Moisture contents shall be determined on materials obtained from each density sample location.

#### 3.14.3 Optimum Moisture and Laboratory Maximum Density

The laboratory maximum dry density shall be determined from materials obtained at a sand cone test location using the appropriate procedure specified in Part 1 above. When ASTM D 1557 is used, the optimum moisture content shall be determined. A minimum of one laboratory maximum dry density test shall be run each placement day or fraction thereof. Additional laboratory maximum dry density tests shall be run for each material change.

### 3.15 CAPILLARY WATER BARRIER

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**NOTE: The compacted thickness of capillary water barrier will be indicated and will not be less than 4**



inches. The paragraph will be deleted where site conditions make the barrier unnecessary.

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Capillary water barrier under concrete floor and area-way slabs on grade shall be placed directly on the subgrade and shall be compacted with a minimum of two passes of a hand-operated plate-type vibratory compactor.

### 3.16 GRADING

Areas within 1500 mm 5 feet outside of each building and structure line shall be constructed true-to-grade, shaped to drain, and shall be maintained free of trash and debris until final inspection has been completed and the work has been accepted.

### 3.17 SPREADING TOPSOIL

Areas outside the building lines from which topsoil has been removed shall be topsoiled. The surface shall be free of materials that would hinder planting or maintenance operations. The subgrade shall be pulverized to a depth of 50 mm 2 inches by disking or plowing for the bonding of topsoil with the subsoil. Topsoil shall then be uniformly spread, graded, and compacted to the thickness, elevations, slopes shown, and left free of surface irregularities. Topsoil shall be compacted by one pass of a cultipacker, roller, or other approved equipment weighing 1.46 kN/m to 2.34 kN/m 100 to 160 pounds per linear foot of roller. Topsoil shall not be placed when the subgrade is frozen, excessively wet, extremely dry, or in a condition otherwise detrimental to seeding, planting, or proper grading.

### 3.18 PROTECTION

Settlement or washing that occurs in graded, topsoiled, or backfilled areas prior to acceptance of the work shall be repaired and grades reestablished to the required elevations and slopes.

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#### ADDITIONAL NOTES

NOTE A: For additional information on the use of all CEGS, see CEGS-01000 CEGS GENERAL NOTES.

NOTE B: This guide specification does not include provisions for separate measurement and payment for any work specified herein. Measurement and payment paragraphs may be provided in the contract specifications when unit-price payment is more equitable for rock excavation, borrow excavation, and the removal and replacement of unsatisfactory material below grades indicated. The guide includes abbreviated specifications for clearing, grubbing, stripping, grading, and topsoiling. If the contract specifications contain separate sections on clearing, grubbing, grading and turf establishment, this section will be revised accordingly.

ASTM reference standards may be replaced by appropriate AASHTO reference standards when local practice is to perform earthwork in accordance with American Association of State Highway Transportation Officials requirements.

NOTE C: Unified soil classification GW, GP, GM, GC, SW, SP, SM, SC, ML, CL, MH and CH will be classified as either satisfactory or unsatisfactory and inserted in the blanks. Whether the materials are satisfactory will depend largely on the climatic and water conditions prevailing at the site, purpose of the fill, and the economic limitations of the project. Determination will be made in accordance with information contained in ASTM D 2487, TM 5-818-1/ AFM 88-3, Chapter 7, and with local experience.

NOTE D: When classification will be necessary during construction, determination of grain size for classification will be specified to be made in conformance with the following:

ASTM C 117 (1987) Materials Finer  
than 75- micrometer  
(No. 200) Sieve in Mineral  
Aggregates by Washing

ASTM C 136 (1984a) Sieve  
Analysis of Fine and  
Coarse Aggregates

ASTM D 422 (1963; R 1972) Particle  
Size Analysis of Soils

NOTE E: Contract specifications for nonfrost-susceptible fill and backfill will state the gradation requirements listed in TM 5-818-2. For fill under critical structures, materials with ML, MH, and CH classification will be specified as unsatisfactory if at all feasible from an economic or material-availability standpoint. If such materials must be used, the specification will point out the critical nature of the materials and the control difficulties to be anticipated. Organic materials and topsoil having OL, OH, and Pt classification will not be used in fill or backfill.

NOTE F: Cross reference must be coordinated with Section 02210 GRADING and Section 02225 EARTHWORK FOR ROADWAYS, RAILROADS AND AIRFIELDS. When spoil areas or borrow areas are within the limits of Government-controlled land, additional requirements based on the following, and as appropriate for the project, will be included in the contract document. Locations of areas will be indicated, or the approximate distances from

the project site will be specified. Generally, unburned vegetative material and surplus excavated material will be disposed of in inconspicuous spoil areas where no future construction is planned. If economically justifiable, surplus suitable excavated material may be stockpiled or may be disposed of in areas where future construction is planned and where fill will be required. Spoil materials will be so placed and the worked portions of spoil areas and borrow areas will be so graded and shaped as to minimize soil erosion, siltation of drainage channels, and damage to existing vegetation. The degree of compaction will be specified.

NOTE G: It is imperative to specify a high degree of compaction in fills under structures to minimize settlement and to insure stability of a structure. In addition to the criteria set forth in TM 5-818-1/AFM 88-3, Chapter 7, the following factors will be considered in establishing the specific requirements:

a. The sensitivity of the structure to total and/or differential settlement as related to the structural design. This is particularly true of structures to be founded partly on fill and partly on natural ground.

b. The ability of normal compaction equipment to produce the desired densities in existing or locally available materials within a reasonable range of molding moisture content. If considered essential, special equipment will be specified.

c. The compaction requirements for clean, cohesionless, granular materials will be generally higher than those for cohesive materials because cohesionless materials readily consolidate when subjected to vibration. For structures with critical stability requirements and settlement limitations, the minimum density requirements may be altered. If only a cohesionless soil or only a cohesive soil is used, the inapplicable values will be deleted.

d. The exception to required high degree of compaction in fills and backfills is in expansive soils (see TM 5-818-7). Where it is necessary to use materials having swelling characteristics, usually CL or CH classifications, the specified degree of compaction will be related to laboratory test results for swelling under a considerable range of molding moisture and compactive effort. In swelling soils, it is important to specify a density and molding moisture range that will enable the soil to stay stable, striking a reasonable balance between potential swell and excessive settlement under load, even at the expense of accepting a reduced bearing capacity. A

maximum permissible density should be established to minimize swelling. If possible, soils with swelling characteristics will be classified as unsatisfactory material, particularly under critical stability structures.

e. ASTM D 1557 is satisfactory for establishing moisture density characteristics of a material in most cases. However, other modifications may be necessary as discussed in this ASTM and under soil tests in DM 21.3/ TM 5-825-2/AFM 88-6, Chapter 2. The procedures and precautions in the subgrade compaction paragraphs of DM 21.3/TM 5-825-2/AFM 88-6, Chapter 2, will be considered in establishing minimum density requirements for a particular project.

Modifications will be made to meet the backfill requirements for deep-seated or subsurface structures as discussed in TM 5-818-4/AFM 88-5, Chapter 5.

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